Technical Memorandum

Phase 1 Evaluation: Significance of Septic Tank Systems on Water Quality in Montana

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for

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Introduction

This evaluation provides background information and a preliminary evaluation of the significance of septic tanks on water quality in Montana. In addition, a discussion is also provided for emerging compounds (e.g., pharmaceuticals) that are becoming an increasing focus of evaluation throughout the United States.

Background

About 35 to 40% of the housing units in Montana utilize on-site wastewater treatment and disposal (US Census Bureau, A). The most common configuration used is a septic tank/drainfield system. This evaluation focuses on domestic systems that treat only domestic wastewater.

Septic tanks treat domestic wastewater by removing most of the floating and settleable material and operate as an anaerobic biologic treatment reactor that provides partial digestion of organic matter. More simply, bacterial populations use organic materials in the effluent as a food/energy source. Septic tank effluent typically contains dissolved organic material, nutrients and biological pathogens (e.g., bacteria and viruses). The effluent would also contain other chemicals, compounds and household products such as pharmaceuticals that are discharged to household drains.

Sewer effluent receives additional treatment when it is discharged to the subsurface soils via drainfields (a.k.a, subsurface absorption fields). Generally, there is additional biological treatment below the drainfields wherein organics and nutrients may be reduced by biological populations. Physical treatment occurs by volatilization, adsorption to soils and filtering processes. Generally, pathogens are retained/removed in subsurface soils.

Typically, effluent from the subsurface absorption field migrates downward and eventually encounters groundwater. In groundwater, the primary physical processes include dilution, dispersion, adsorption and volatilization. Further biological transformations (e.g., denitrification) may occur in the groundwater regime but to a lesser extent.

Generally, septic systems are effective if properly sited, installed and maintained (US EPA, 1980), (US EPA, 1997)(US EPA, 2002), (Morrison-Maierle, 2008). A key factor is that a sufficient area (e.g., a mixing zone with sufficient lot size) is required to allow physical processes of dilution and dispersion to reduce nutrient concentrations to acceptable levels. Nitrates tend to be stable in groundwater, therefore, cumulative effects may develop with increased septic tank density.

Potential water quality impacts from septic tanks are normally associated with nitrates. Nitrates are a relatively conservative compound that poses both human health and ecological risks. Nitrates in groundwater above drinking water standards (a.k.a. Maximum Contaminant Levels [MCL]) and used as a drinking water source can cause blue baby syndrome, and other health problems for pregnant women. Note that the MCL for nitrate is 10 mg/L. Nitrates and phosphorus discharged into surface waters directly or through groundwater flows can lead to increased algal growth and low dissolved oxygen levels.

Nitrogen Cycle

Nitrogen, in the form of nitrogen gas (N2), is the most abundant element in the atmosphere. Nitrogen is an essential component of biological life. Nitrogen is a key element in plant photosynthesis. The earth's atmosphere consists of about 78 to 80% nitrogen gas. However, animals and plants do not use this form of nitrogen, but rather inorganic forms such as ammonium and nitrates. Nitrogen leaves the atmosphere via precipitation and lightening strikes (N2 to nitrates). Nitrogen from precipitation is then fixed in the soil into inorganic forms by microorganisms. The inorganic nitrogen is used by plants and then in turn by animals for growth. Nitrogen is returned to the soils in the form of organic nitrogen, including plant debris and animal waste. Nitrogen is returned to the atmosphere by the process of denitrification (inorganic nitrogen converted to gas by biological processes).

Human Interaction on Nitrogen Cycle

The key human activities affecting the nitrogen cycle include:

- Agriculture (cultivation of legumes, production of fertilizer, livestock waste)
- Emissions (burning fossil fuels)
- Human wastewater

Nitrogen Mass Balance

Since the natural nitrogen cycle dominates the mass balance, a rigorous mass balance of the complete cycle is not especially instructive. However, quantification of the relative contributions of human sources does provide insight into the relative impacts of specific activities.

In Montana, the key sources of increased nitrogen to surface and groundwater include:

1) Fertilizers: Total nitrogen of 203,000 tons (Montana Department of Agriculture, 2008)
2) Livestock: Cattle - 2,600,000; Swine - 175,000; Sheep - 255,000 (US Department of Agriculture, 2007)
3) Humans:
   a) Population: 2008 estimate - 967,440 (US Census Bureau, B)
   b) Housing Units: 2008 - 438,282 (US Census Bureau, C)

A cow produces about 11 tons of manure annually, of which about 0.57 % is nitrogen. The total cattle nitrogen production is 162,000 tons per year (based upon data presented in Land & Water Consulting, 1996).

Humans produce about 12.2 pounds of nitrogen per year, resulting in total in Montana of about 6,000 tons per year (Peavy et al, 1985). Of this amount, about 37% or 2,159 tons is discharged to septic tanks.

Contributor	Tons of Nitrogen	Percent of Total
Fertilizer	203,000	54.7
Livestock (cattle)	162,000	43.7
Humans (public wastewater systems)	3,840	1.0
Humans (septic tanks)	2,160	0.6
TOTAL	371,000	

Montana Regulations

Septic tanks are regulated on both a state and county level. The Montana Department of Environmental Quality (DEQ) reviews subdivisions that propose to utilize septic systems. Approving subdivisions served by septic systems includes review of impacts to ground and surface water per water quality non-degradation regulations. The actual permitting of a septic system installation is at the county level. An engineer or certified septic installer submits information to the county for review to obtain a permit.

A new discharge is regulated under Montana non-degradation laws. A key issue is that a treatment system aggregates sewer effluent from a larger area to one discharge location. Thus, advanced and expensive treatment may be required to attain discharge limits. For example, the City of Bozeman's ongoing wastewater treatment plant upgrade is expected to cost about $ 54 million (Bozeman Chronicle, 2008).

Advanced On-Site Treatment Systems

Typical septic systems are designated as a Level 1 system. Systems are ranked according to their effectiveness in treating nitrate. Montana DEQ rules assign the following nitrate effluent concentrations for use in required non-degradation evaluations

Level 1	50 mg/L	Typical septic systems
Level 1a	40 mg/L	
Level 1b	30 mg/L	Intermittent sand filters
Level 2	24 mg/L or less	Recirculating sand filters and approved proprietary systems

DEQ has an established process for certifying proprietary Level 2 systems. Current approved systems include:

- Orenco – AdvanTex
- Fluidyne – Eliminite
- International Wastewater Systems (IWS) model 6000 sequencing batch reactor
- Santec – Extended Aeration (approved for nitrogen reduction to 14 mg/L)
- Bio-Microbics – Micro-FAST and Retro-FAST
- HDR Engineering Activated Sludge / Biological Nutrient Reduction Systems (approved for nitrogen reduction to 10 mg/L)

- International Wastewater Systems (IWS) model 6000 sequencing batch reactor with methanol addition, coagulation and filtration (approved for nitrogen reduction to 7.5 mg/L)
- NORWECO Singulair Model TNT
- HDR Engineering Activated Sludge / Biological Nutrient Reduction / Membrane Filtration Systems (approved for nitrogen reduction to 7.5 mg/L).

Nicklin Earth & Water (NE&W) is also familiar with recent work being undertaken by Water and Environmental Technologies (WET) from Butte, Montana, involving research and commercialization of SepticNET™ Nutrient removal technology. Pilot testing efforts are reported to be promising. According to our communications with WET, the company's goal is to have this technology approved in the near future by DEQ so that it can be commercially available near the end of 2010.

Evaluation of Pertinent Literature

NE&W searched and evaluated scientific studies potentially related to septic tanks from local and national sources including:

- US Environmental Protection Agency (EPA)
- U.S. Geological Survey (USGS)
- Montana Department of Environmental Quality (DEQ)
- Montana Local Water Quality Districts
- Montana State University Library
- General internet search

Additionally, NE&W is also familiar with both surface water and groundwater quality issues from projects in which we have been involved in Montana.

Generally, most of the more recent studies are associated with the Montana Total Maximum Daily Load (TMDL) program and evaluations of the potential impacts from household products and pharmaceuticals. The process of the TMDL program includes assessing the water quality of surface water reaches in comparison to "reference" waters. As may be expected, streams flowing in areas with more agricultural use and human population tend to have lower water quality when compared to streams in pristine areas. Once a stream is designated as impaired, the process calls for development of maximum loads to improve or maintain water quality. Typically, these loading restrictions have been applied to point sources such as municipal treatment systems as it is difficult to control non-point sources such as agriculture.

The literature review also identified various EPA septic tank guidance and design manuals. The more recent efforts tend to focus on proper management of septic systems to minimize potential impacts on surface water.

Three studies that we determined to have specific relevance include:

1) The Effects of Septic Systems on Surface Water and Ground Water in Two Subdivisions in the Gallatin County Local Water Quality District, Montana, Kerri Rae Fleming, Montana State University Masters Thesis, April 2003.

Summary: This study evaluated the water quality related to septic tanks at two existing subdivisions in the Gallatin Valley. Generally, the study showed very little evidence of water quality impacts to groundwater and surface water that could be attributed to septic tanks. Nitrate isotope testing indicated that the source of nitrate in groundwater was likely associated with soil nitrogen and/or fertilizers. More information on this study is presented in Attachment A.

2) Magnitude, Extent, and Potential Sources of Nitrate in Ground Water in the Gallatin Local Water Quality District, Southwestern Montana, 1997-1998, Kendy, Eloise, USGS Water-Resources Investigations Report 01-4037.

Summary: This study, focused on nitrates, evaluated the impact of septic tanks on groundwater. Evaluation of nitrate isotope data showed that the major source of nitrate to be soil organic nitrogen and fertilizers, not septic tanks. The study also looked at three existing subdivisions in the Gallatin Valley and concluded that septic effluent did not appear to be a major source of nitrate to groundwater. More information on this study is presented in Attachment A.

3) Nitrate in the Ground Water and Surface Water of the Summit Valley near Butte, Montana, LaFave, John, Montana Bureau of Mines and Geology, Ground-Water Open-File Report 22 (2008).

Summary: This study focused on nitrates and evaluated the impact of septic tanks and municipally-sewered systems on groundwater and surface water. Evaluation of the nitrate isotope data showed this to be one example where a combination of a leaking municipally-sewered system (within Butte) and septic systems have added measurable levels of nitrates to both the groundwater and surface water. Key factors that contributed to the conditions include both the type of geologic conditions present and the density of development. The relevant geologic condition involves soils which had historically been predicted to be of poor suitability for septic tank systems prior to development. Hence, if those factors had been considered prior to development, perhaps the resulting impacts could have been minimized or avoided altogether. More information on this study is presented in Attachment A.

4) Other studies

NE&W also communicated with Mr. Eric Regensberger of the DEQ about areas where nitrates have been a groundwater quality issue. Mr. Regensberger named the Summit Valley discussed above (LaFave, 2008). Another location included a subdivision between Norris, Montana, and Four Corners, Montana. Based upon the descriptions that were provided, the last location possesses geologic conditions that are similar to those present in the Summit Valley. NE&W also notes that the location was formerly agricultural. NE&W is unaware whether isotope analysis has been conducted in order to define the source of the nitrates that are present. Another site described by Mr. Regensberger included the River Rock subdivision near Belgrade, Montana. NE&W notes that the River Rock subdivision does not use septic tanks but rather relies on a lagoon system for disposal/treatment of wastewater effluent. Other locations described by Mr. Regensberger tended to be more directly associated with historic agricultural settings that included use of fertilizers and animal feedlots. The resulting high initial nitrate conditions from such agricultural uses would lead to more stringent restrictions if housing developments were proposed in those areas.

NE&W is aware of other studies that have been conducted in the State of Montana relative to nitrate issues involving subdivisions. These include, but are not necessarily limited to, the following:

> "Evaluation of Unsewered Areas in Missoula, Montana" prepared by the Missoula Valley Water Quality District Environmental Health Division, Missoula City-County Health Department (March 1996).
>
> and
>
> "Helena Valley Ground Water: Pharmaceuticals, Personal Care Products, Endocrine Disruptors (PPCPs) and Microbial Indicators of Fecal Contamination" by K. J. Miller and J. Meek both of the Montana Department of Environmental Quality (March 2006).

The Missoula study focuses on nitrate contamination and uses mass balance approaches to project nitrate loading throughout the Missoula area. Very general statistics are presented in the report and they show that nitrate concentrations are relatively low - far less than the MCL threshold. The report argues that nitrate concentrations tend to increase progressing through the developments. However, it would be necessary to conduct isotope analysis to determine the source of the nitrate before attributing it to septic tanks as opposed to other potential sources such as lawn fertilizers. For instance, isotope analysis in other areas has demonstrated that there can be multiple potential sources of nitrate (e.g., fertilizer, animal waste, industrial, etc.).

The second study (Miller and Meek) provides information on both nutrients, inorganics and pharmaceuticals, personal care products, endocrine disruptors, which they collectively coin as PPCPs, for the Helena valley area. The focus of this study was on PPCPs. Discussion on this aspect of the Miller and Meek study is presented at the end of Attachment A. Some discussion of the Miller and Meek study is also presented at the end of the next section below.

Emerging Contaminants

Recent research documents that other chemical and microbial constituents that have not been historically considered as contaminants are present in the environment on a global scale. These "emerging contaminants" are commonly derived from municipal, agricultural and industrial wastewater sources and pathways. These newly recognized contaminants represent a shift in traditional thinking as many are produced industrially yet are dispersed to the environment in a variety of ways, including domestic, commercial, and industrial uses (http://toxics.usgs.gov/regional/emc/).

According to the USGS, one key type of compound may cause endocrine disruption in animal species, including fish. In the case of fish, this endocrine disruption may result in what is known as "intersex," or the presence of both male and female characteristics within the same fish. Endocrine disruption can also result in adverse effects on the development of the brain and nervous system, the growth and function of the reproductive system, and the response to stressors in the environment.

There are a variety of potential sources to these disrupters, including the following: municipal effluent, municipal biosolids, municipal holding ponds, septic tanks, hospital waste, agricultural (poultry, swine, dairy, cattle operations), aquaculture and other waste sources.

It appears that most of the research involving endocrine disruption is focused on the larger sources such as municipal effluent and agricultural operation impacts. The studies tend to be relatively recent and ongoing. Again, some of the USGS research activities can be found at the following link:

http://toxics.usgs.gov/regional/emc/

Some preliminary results of recent research can also be found by examining the link below. In particular, a sublink focuses on groundwater quality studies:

http://toxics.usgs.gov/highlights/gwsw_ec.html

For instance, according to the USGS:

> Ground-water samples were collected from a network of 47 wells with common environmental conditions and which typically were not used for drinking water. The wells, in 18 states, were analyzed for 65 chemicals. The most frequently detected chemicals include N,N-diethyltoluamide (insect repellant), bisphenol A (plastic- and epoxy-manufacturing ingredient), tri(2-chloroethyl) phosphate (fire retardant), sulfamethoxazole (veterinary and human antibiotic), and 4-octylphenol monoethoxylate (detergent metabolite). The concentrations of chemicals detected were low. Eighty-seven percent of the 137 measured detections were less than 1 microgram per liter (µg/L). Mixtures of chemicals were common. Although similar chemicals were detected in the previous national stream reconnaissance, the chemicals were detected less frequently in this study's ground-water sites (35 percent of the sites) than they were in the stream reconnaissance (86 percent of the sites).

This may suggest that the most significant sources of chemical impact are from either wastewater treatment plant effluent or surface water runoff (e.g., agricultural, feedlots, etc.). This is also suggested by the following link:

http://toxics.usgs.gov/highlights/fish_endocrine_disruption.html

Some conclusions of the studies include the following:

> . . . documented that the population of fish <u>downstream of the wastewater discharge from a sewage treatment plant</u> was dominated by females, and 18 to 22 percent of fish exhibited intersex. (Underlined for emphasis).

> They also found that higher incidence of intersex occurred in streams draining areas with <u>intensive agricultural production and high population</u> when compared to non-agricultural and undeveloped areas. (Underlined for emphasis).

One of the more detailed studies was conducted by the Snyderville Basin Water Reclamation District (SBWRD) at its wastewater treatment facility near Park City, Utah. Although this study does not focus on endocrine disrupter compounds (EDCs) in groundwater affected by septic tanks, it does insights about the significance of septic tanks.

The effluent from the SBWRD treatment plant was determined to contain EDCs. The SBWRD had considered developing a treatment system to address the EDCs. However, the cost of such treatement was determined to be very high. As a result of the projected high cost, SBWRD conducted a study to determine if there was any evidence of estrogenic or intersex effects for the fish in East Canyon Creek downstream from the treated wastewater effluent. The results of this study were used to determine if there was any merit in the projected high cost for even employing more advanced treatment methods.

The key components of this study included the following:

- Municipal treatment system discharging an effluent from 3.28 (October) to 6.28 (April) cfs.

- The receiving stream, East Canyon Creek had an average monthly flow of 12.07 cfs and 114.13 cfs in August and May respectively.

In effect, the relative degree of dilution from incoming streamfow is lower during the later portion of the irrigation season (e.g., August through October). In other words, a substantial portion of the streamflow in East Canyon Creek downstream is from waste water treatment plant discharge.

The following tests on fish were performed:

- Sentinel study where 50 rainbow trout were placed directly in the final effluent from the treatment plant (not in stream).
- A negative control where 50 rainbow trout were placed at the up-gradient end of a fish hatchery.

The results of the SBWRD study indicated that the presence of EDCs did not trigger a biological response known as vitellogenesis (a response caused by potent estrogens). In a nutshell, even though the sentinel trout had been placed directly into treated plant effluent before it was diluted by East Canyon Creek, there was no statistically significant difference in sentinel group when compared to the trout of the negative control group.

Another portion of the study was to test brown trout collected within East Canyon Creek (upgradient and downgradient). A small dam exists above the treatment facility which allowed for collection of brown trout above and below the dam. Again, the results of the testing did not yield any statistically significant evidence of EDC effects on the brown trout population.

There are other tests being performed as well but the results of those studies have not been completed.

If it is assumed that the SBWRD study produces results which are representative of conditions of wastewater treatment plants in Montana, it is our preliminary conclusion that EDCs related to wastewater are unlikely to be a significant problem for fisheries in Montana. One reason for this conclusion is that denser portions of Montana's population tend to be located near streams which possess much larger flows than East Canyon Creek (e.g., Bitterroot River, Clark Fork River, Gallatin River, Missouri River, etc.). In essence, the relative impacts of EDCs should be much lower because of the simple process of dilution.

In the case of septic tanks, a similar chemical mass balance approach could be employed to determine the relative significance for EDCs to be a potential concern on nearby surface waters. For instance, insights can be made from a recent case study conducted on the groundwater of the Helena Valley by the DEQ (see Attachment A). This study included the collection of some of the same EDCs that had been collected in the SBWRD study. In general, the median Helena Valley groundwater concentrations for EDCs were generally substantially lower than what was observed in the treated waste water effluent of SBWRD. Hence, it is rational to conclude at this stage that if the Helena Valley is representative of the conditions in other developed areas of Montana that EDCs are unlikely to be a substantive problem. More research is warranted however in order to provide more definitive conclusions.

In closing, one of the better ways to reduce the potential for EDCs in wastewater, including discharge from septic tanks, is to educate the public in order to reduce and/or eliminate the likelihood that such chemicals would be dispensed or disposed of in bathroom toilets, sinks, etc.

Comments and Recommendations

1) Septic tank systems for residential use are effective if proper siting, construction and maintenance practices are followed.

2) The effectiveness of septic tanks decreases with increasing numbers in a given area. Effectiveness may also correlate in direct proportion to lot size.

3) The impacts associated with septic tanks are minor when compared to other impacts (e.g., agriculture). In most situations where nitrates are an issue, they are much more likely to be related to existing and/or prior agricultural practices. Based upon our communications with DEQ, two locations in Montana were identified where evidence supports the conclusion that relatively higher nitrate concentrations were attributable to septic tanks. One location is the Summit Valley in the Butte area and another is near Norris, Montana. The isotopic analysis on groundwater data for the Summit Valley also confirms that wastewater from both sewered and septic tanks are likely contributors to nitrate concentrations.

   There are a large number of subdivisions that exist in Montana that utilize septic tank treatment systems. Yet, aside from the Summit Valley and the Norris locations, we are unable to find confirmatory evidence that the relative impact from septic tank systems on groundwater and surface water quality is a significant problem in Montana, especially when compared to agricultural uses which tend to be the dominant contributor to nutrient loading of groundwater and streams in this state.

4) More advanced on-site treatment systems are available to provide increased treatment efficiency for applicable situations. Also, there are emerging technologies (e.g., SepticNET™, etc.) that enable treatment of septic tank effluent to levels comparable to public or community wastewater treatment systems.

5) Research has indicated that pharmaceuticals, personal care products, endocrine disruptors (PPCPs) are present in both surface waters and groundwater of Montana. Based upon the available information, the detection frequency and concentrations are low for most of the compounds. The USGS has drawn

similar conclusions in its studies elsewhere in the United States. Nonetheless, it is warranted to inform the public of proper disposal methods for these PPCPs to reduce in any potential risk that may arise.

Summary

Septic tank systems for residential use are effective if proper siting, installation and maintenance practices are followed. Based upon the information examined by NE&W, there does not appear to be a statewide nitrate contamination problem that can be attributed directly to septic tanks. Rather, the most significant nitrate issues tend to be associated with agricultural practices.

Regulators have options for implementing more advanced treatment for septic tanks. There are emerging technologies that show promise to further improve the treatment capabilities of on-site systems.

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Attachment A - Case Studies

Case Study 1 - Gallatin Valley

Project or Report Title:

The Effects of Septic Systems on Surface Water and Ground Water in Two Subdivisions in the Gallatin County Local Water Quality District. Kerri Fleming, Masters Thesis, April 2003 under the direction of Dr. Steve Custer of Earth Sciences Department at Montana State University.

Locations:

Subdivision Area 1: Middle Creek Study Area

Subdivision Area 2: Gardner/Sourdough Area

Methods:

Surface Water Sampling
Groundwater Sampling

Analytes include (but not limited to):

Nitrate/Nitrate as Nitrogen
Total Kjeldahl Nitrogen (Ammonia) Analysis
Orthophosphate Analysis
Total Coliforms
Chloride
Nitrogen Isotope Analysis (allows defining type of source whether animal or fertilizer).

Shallow groundwater wells were installed to yield a "worst case" assessment under a hypothesis that shallower portions of the underlying aquifer would more likely be impacted from shallow or surface sources of contamination (e.g., fertilizer, animal feedlots, septic tanks, etc.).

Both subdivisions examined were located near streams to determine if there was any degradation of streams that could be directly attributable to septic tanks.

Results

1. Middle Creek Study Area

A total of 58 groundwater samples from domestic wells were collected in the Middle Creek area. Another 8 samples were collected from monitoring wells. A key parameter used in ground water non-degradation evaluations is nitrate. The general statistics of each are the following:

Domestic Wells

Mean concentration	(1.49 mg/L or ppm)
Median concentration	(1.41 mg/L)
Range in concentration	(0.94 to 2.68 mg/L).

Monitoring Wells

Mean concentration	(1.67 mg/L or ppm)
Range in concentration	(0.94 to 2.15 mg/L).

Note that maximum contaminant level (MCL) for nitrate is 10 mg/L or (10 ppm).

Summary: The study concluded that nutrient values are low in the groundwater beneath and down-gradient of this subdivision. They were well below the MCLs. There was no obvious down flow increases in contaminant levels to indicate a substantive septic tank influence.

2. Gardner/Sourdough Study Area

A total of 20 groundwater samples from domestic wells were collected in the Gardner/Sourdough Study Area. Another 4 samples were collected from monitoring wells.

A key parameter used in groundwater non-degradation evaluations is nitrate. The general statistics of each are the following:

Domestic Wells

Mean concentration	(1.04 mg/L or ppm)
Median concentration	(0.94 mg/L)
Range in concentration	(0.53 to 1.99 mg/L).

Monitoring Wells

Mean concentration	(1.57 mg/L or ppm)
Range in concentration	(0.45 to 3.54 mg/L).

Note that MCL for Nitrate is 10 mg/L or (10 ppm).

Summary: The study concluded that nutrient values are low - well below the MCL. Like the Middle Creek study area, there was no obvious down flow increases in contaminant levels to indicate a substantive septic tank influence.

Both of the subdivision cases described above provided no evidence that streams were being measurably affected by septic systems.

Case Study 2 - Gallatin Valley

Project or Report Title:

Magnitude, Extent and Potential Sources of Nitrate in Ground Water in the Gallatin Local Water Quality District, Southwestern, Montana, 1997-98. U.S. Geological Survey Water-Resources Investigations Report 01-4037 by E. Kendy.

Locations:

Hyalite Heights subdivision
Baxter Creek subdivision
Royal Arabian subdivision

It should be noted that in addition to samples being collected from the vicinity of the above subdivisions, samples were also collected throughout the Gallatin Local Water Quality District.

Methods:

Groundwater Sampling

Analytes included (but were not necessarily limited to):

Nitrate/Nitrate as Nitrogen
Chloride
Nitrate (field)
Nitrogen Isotope Analysis (allows defining type of source whether animal, fertilizer, etc.)
Oxygen Isotope Analysis (allows age dating of groundwater to better assess timing of recharge)

Results

1. Gallatin County Local Water Quality District Samples

Median concentration	(< 3 mg/L or ppm)
Range in concentration	(< 0.5 to 13 mg/L). 2 samples showed nitrate concentrations exceeding 10 mg/L.

Concentrations in basin fill deposits where most residents obtain their water was from 0.18 to 8.1 mg/L. Note that MCL for nitrate is 10 mg/L or (10 ppm).

2. Subdivision Evaluations

Royal Arabian (adapted from results present in Figure 18 of the USGSreport)

Mean concentration	(0.50 mg/L)
Median concentration	(0.42 mg/L)
Range in concentration	(0.08 to 1.3 mg/L).

Nitrate concentrations are very low in the vicinity of this subdivision. The MCL is 10 mg/L.

Note that the report did not explicitly present data in a form that the above statistics could be developed for the two other subdivisions - Baxter Creek and Hyalite Heights.

Summary

According to this report, "Potential sources of nitrate to ground water include runoff or infiltration of timber harvests, atmospheric deposition, livestock waste, fertilizer, soil organic nitrogen, and domestic septic-system effluent. However, fertilizers and soil organic nitrogen probably contribute most of the nitrate to ground water in the Gallatin County Local Water Quality District."

Case Study 3 - Summit Valley

Project or Report Title:

Nitrate in the Ground Water and Surface Water of the Summit Valley near Butte, Montana, LaFave, John, Montana Bureau of Mines and Geology, Ground-Water Open-File Report 22 (2008).

Locations:

Summit Valley

Sewered areas
Unsewered areas (includes subdivisions dependent upon septic tanks)

Methods:

Groundwater Sampling
Surface Water Sampling

Analytes include (but not necessarily limited to):

Nitrate-N (nitrate plus nitrite)
Chloride
Nitrate (field)
Nitrogen Isotope Analysis (allows defining type of source whether animal, fertilizer, etc.).
Oxygen Isotope Analysis (allows additional assessment on source of nitrate).

Results:

1. All areas of valley

Median concentration (3.18 mg/L or ppm)
Range in concentration (< 0.01 to 44.7 mg/L).

The MCL for nitrate is 10 mg/L or (10 ppm). Thirty two samples out of a total of 239 samples were at concentrations exceeding the MCL.

2. Sewered Areas (within sewer service area of Butte).

Median concentration (4.8 mg/L)
Range in concentration (< 0.05 to 40.12 mg/L).

Note that 19 % of the samples exceeded the MCL of 10 mg/L.

3. Un-sewered Areas (outside Butte sewer service area) which includes subdivisions.

   Median concentration (2.5 mg/L).
   Range in concentration (< 0.01 to 44.7 mg/L).

   Note that 8 % of the samples exceeded the MCL of 10 mg/L.

   Based upon the overall summary, the nitrate impacts to ground water and surface water tended to be more severe in the sewered areas (municipal) versus the non-municipal areas. There were two subdivisions known as Lyndale Acres and Warne Heights which showed elevated nitrate concentrations. The median concentrations at these two subdivisions were 4.29 and 6.72 mg/L. Three wells out of a total of 30 wells sampled indicated nitrate concentrations exceeding the MCL of 10 mg/L.

4. Isotope testing was conducted on 24 wells showing elevated concentrations of nitrates. The results of this isotope analysis indicated that the wells showing relatively higher concentrations of nitrate included animal sources (humans or other animals).

5. The surface water was also deemed to be impacted by nitrates. Based upon information presented in this report (Figure 14) it appears that the most significant impact to the streams was associated with groundwater flowing into the streams from the sewered areas.

Summary:

According to LaFave, the most likely potential nitrate sources in the Summit Valley include fertilizers applied to lawns, leaky sewer pipes and septic effluent.

Other Studies

NE&W is aware of other studies that are being performed in the State of Montana relative to nitrate issues involving subdivisions. These include, but are not necessarily limited to, the following:

> "Evaluation of Unsewered Areas in Missoula, Montana" prepared by the Missoula Valley Water Quality District Environmental Health Division, Missoula City-County Health Department (March 1996).
>
> and
>
> "Helena Valley Ground Water: Pharmaceuticals, Personal Care Products, Endocrine Disruptors (PPCPs) and Microbial Indicators of Fecal Contamination" by K. J. Miller and J. Meek both of the Montana Department of Environmental Quality. March 2006.

The first study focuses on nitrate contamination and uses mass balance approaches to project nitrate loading throughout the Missoula area. Very general statistics are presented in the report and they show that average nitrate concentrations are relatively low being far less than the MCL. The report states that nitrate concentrations tend to increase progressing through the developments. However, more information is required for this argument to be definitive. There is no evidence that isotope analysis akin to the work performed in the previous studies discussed above was performed for this study. For instance, there are multiple potential sources of nitrate including fertilizer, animal source, industrial, etc.

The Miller and Meek study focused on a combination of inorganic and organic compounds including pharmaceuticals, personal care products and endocrine disruptors (PPCPs). PPCPs were found at various frequencies depending upon the compounds (see table that follows). NE&W compared constituents from the Miller and Meek study to concentrations of the wastewater effluent from the Snyderville Basin Water Reclamation District study. Constituents common to each study which could be compared include the following:

Compound	Miller and Meek (number detected)	Detection Range *	Snyderville - treated effluent concentrations
Estrone	1 of 32	< 1.0 to 1 (ng/L)	< 1.0 (ng/L)
Ethinyl Estradiol - 17a	0 to 32	< 2	< 1.0
Progesterone	1 of 32	< 0.5	< 1.0
Testosterone	0 of 32	< 2	< 1.0
Caffeine	5 of 32	< 5 to 21	8.5 to 25
Carbamazepine	15 of 32	< 0.5 to 420	48 to 280
Diazepam	0 of 32	< 0.5	< 1 to 300
Fluoxetine	3 of 32	< 1 to 21	< 1 to 28
Gemfibrozil	2 of 32	< 1 to 3.8	52 to 78
Ibuprofen	8 of 32	< 10 to 92	20 to 57
Sulfamethoxazole	18 of 32	< 0.5 to 490	820 to 1,400
Triclosan	1 of 32	< 5 to 5.5	31 to 43
Trimethoprim	5 of 32	< 1 to 3.1	11 to 22

* Nanogram per liter (ng/L). Note that this is the equivalent of a part per trillion.

The primary purpose of this comparison was to note that the Snyderville study specifically evaluated the impacts of its treated wastewater effluent on the rainbow and brown trout in East Canyon Creek. It is noteworthy that the Snyderville study concluded that there was no statistically significant evidence of Endocrine disruption on rainbow trout placed directly in the treated wastewater effluent. Similarly, there was no evidence that brown trout in East Canyon Creek were affected. Yet, the concentrations of the endocrine disruptors tend to be much higher for the wastewater effluent than in the groundwater tested in the Helena Valley.

In effect, the following are noteworthy considerations:

- Relatively low concentrations of EDCs in the Helena Valley aquifer compared to Snyderville study;
- Relatively low level of frequency of EDC detections; and
- Relative degree of dilution that will occur as groundwater enters effluent streams. It does not appear at this stage of the investigation that there is any substantive basis to conclude that there would be Endocrine disruption associated with groundwater flux into nearby streams of the Helena Valley. The ongoing studies of others throughout the country, including the USGS, may shed additional light on this issue in the near future.